Ann Ist Super Sanità 2026 | Vol. 62, No. 3: 217-223
DOI: 10.4415/ANN_26_03_04

Incidence and factors associated with bystander cardiopulmonary resuscitation in out-of-hospital cardiac arrest in an Italian region

Matteo De Vecchi[1], Ines Basso[2], Tommaso Davite[3], Erika Bassi[2], Erica Busca[2], Silvano Andorno[2], Luca Briacca[2], Carla Vigliano[4], Rosanna Vaschetto[2], Daniele Privitera[5], Laura Rubino[6], Salvatore Izzo[6], Roberto Gioachin[7*] and Alberto Dal Molin[2*]

[1]*Dipartimento Emergenza Urgenza, Azienda Socio-Sanitaria Territoriale Grande Ospedale Metropolitano Niguarda, Milan, Italy*
[2]*Dipartimento di Medicina Traslazionale, Università degli Studi del Piemonte Orientale "Amedeo Avogadro", Novara, Italy*
[3]*Dipartimento di Emergenza Urgenza, Azienda Socio-Sanitaria Territoriale Ovest Milanese, Magenta, Italy*
[4]*Dipartimento di Emergenza-Urgenza e Accettazione, Azienda Ospedaliero-Universitaria SS. Antonio e Biagio e Cesare Arrigo, Alessandria, Italy*
[5]*Department of Life Sciences and Medicine, Faculty of Science, Technology and Medicine, University of Luxembourg, Esch-sur-Alzette, Luxembourg*
[6]*Dipartimento di Emergenza Urgenza, Azienda Ospedaliero-Universitaria Maggiore della Carità, Novara, Italy*
[7]*Dipartimento Management e Gestione Reti di Emergenza, Azienda Sanitaria Zero, Torino e Novara, Italy*
**These Authors should be considered co-last Authors*

Abstract

Introduction. Out-of-hospital cardiac arrest (OHCA) is a major cause of mortality, and early bystander cardiopulmonary resuscitation (CPR) is critical for survival. This study assessed OHCA incidence and factors associated with bystander-initiated CPR in the Piedmont region of Northern Italy.

Methods. A retrospective cross-sectional analysis was conducted using 2022 administrative data from an Emergency Medical Dispatch Centre serving 851,538 residents. All confirmed OHCA cases were included. Demographic, clinical, and contextual variables were extracted. Descriptive statistics summarized case characteristics, and comparisons between events with and without bystander CPR were performed using chi-square or Fisher's exact tests.

Results. Among 905 confirmed cases, the incidence was 106 per 100,000 inhabitants. Most patients were male (57%), with a mean age of 76 years, and arrests occurred predominantly at home (87%). Bystander CPR was documented in 644 cases, occurring in 39.9%, mainly independently. CPR was more frequent in rural areas (p=0.002) and public settings (p<0.001). Return of spontaneous circulation occurred in 6.4% and was strongly associated with bystander intervention (p<0.001).

Conclusions. Fewer than half of eligible patients received bystander CPR, highlighting gaps in community readiness. Strengthening public training and dispatcher-assisted CPR may improve outcomes.

Key words

- out-of-hospital cardiac arrest
- emergency medical services
- cardiopulmonary resuscitation
- prehospital care
- retrospective studies
- CPR in Italian OHCA

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) is a major global health challenge and represents the third leading cause of death in industrialized countries [1, 2]. Its global incidence ranges from 30 to 170 cases per 100,000 inhabitants annually [3-5], with marked variation across countries and regions, largely attributable to differences in data collection, population characteris-

Address for correspondence: Ines Basso, Dipartimento di Medicina Traslazionale, Università degli Studi del Piemonte Orientale "Amedeo Avogadro", Via Solaroli 17, 28100 Novara, Italy. E-mail: ines.basso@uniupo.it.

tics, and emergency care systems. This heterogeneity is particularly evident in Italy, where the absence of a national cardiac arrest registry has resulted in fragmented epidemiological information [6]. Despite advances in resuscitation and post-arrest care, survival remains low, with an overall rate of approximately 8% and favourable neurological outcomes in fewer than 3% of patients at hospital discharge [7].

It is estimated that about half of OHCAs are witnessed by bystanders [8]. When promptly initiated, cardiopulmonary resuscitation (CPR) and the use of semi-automatic external defibrillators (AEDs) by lay responders represent the most critical link in the chain of survival [9]. Bystander CPR significantly improves outcomes, with immediate initiation after collapse, even before AED deployment, associated with a two- to threefold increase in survival probability [10, 11].

Several community-based projects worldwide have aimed to improve awareness among both adults and children about recognising OHCA and promptly initiating resuscitation [12-14]. Nevertheless, despite these initiatives, the proportion of people in Europe who provide resuscitation while awaiting professional assistance varies widely, ranging from 17% to 78% [15].

Multiple factors influencing the likelihood of bystanders initiating resuscitative manoeuvres have been identified in the literature [16]. These include sociodemographic variables (age, gender, and level of education), contextual circumstances (location of the arrest, presence of other witnesses, relationship to the victim), psychological aspects (confidence, fear of harming the victim, or fear of legal consequences), and practical factors (prior CPR training, availability of AEDs, and dispatcher-assisted CPR) [17-21]. Importantly, many of these determinants are modifiable. For example, public training campaigns, integration of CPR teaching into school curricula, and dispatcher-assisted instructions have been shown to improve laypeople's willingness and ability to intervene, whereas broader availability and accessibility of AEDs address infrastructural barriers [2]. Conversely, factors such as advanced age of the bystander or a familial relationship to the victim, which may be associated with higher emotional distress, are more difficult to modify [17]. Despite this knowledge, existing evidence remains incomplete and strongly shaped by contextual factors such as healthcare organization, cultural attitudes, and local infrastructure [22]. Such variability suggests that a deeper understanding of context-specific dynamics could provide valuable insights for improving bystander intervention.

In Italy, the pre-hospital emergency service is publicly funded and organized on a regional basis within the framework of the National Health Service. To improve efficiency and resource management, since 2021, in the Piedmont region, the system has been coordinated by Azienda Zero. Emergency calls are managed by four medical dispatch centres, which assess case severity, coordinate the most appropriate response, and, in the event of OHCA, provide CPR instructions to laypeople [23].

To the best of our knowledge, no recent studies have investigated the occurrence of OHCA and the rate of bystanders-initiated CPR in the Piedmont region [6]. In the absence of a national registry, recommended by international guidelines [24], collecting local data is essential to gain insights into this event, thereby informing emergency service organization and guiding targeted public awareness initiatives [6]. Accordingly, this study aimed to: i) estimate the incidence and outcomes of OHCA cases managed by an Emergency Medical Dispatch Centre in Piedmont; ii) determine the proportion of events in which bystanders initiated CPR prior to Emergency Medical Services (EMS) arrival; and iii) compare the characteristics and outcomes of cases with and without bystander-initiated CPR.

METHODS

Study design

We conducted a retrospective cross-sectional study based on administrative data from an Emergency Medical Dispatch Centre in the Piedmont region. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [25].

Setting

We collected data between January 1 and December 31, 2022, from an Emergency Medical Dispatch Centre in Piedmont, serving a catchment population of 851,538 residents across five provinces [12]. The centre manages an average of 250-300 emergency calls per day. Prehospital coverage is provided by approximately 60 basic life support (BLS) ambulances, staffed by emergency medical technicians with regional rescue qualifications, and 18 advanced life support (ALS) ambulances, staffed by physicians and/or critical care nurses. Additional support is ensured by a helicopter emergency medical service, staffed by an anesthesiologist-intensivist, a critical care nurse, and a technician from the Alpine and Speleological Rescue Service.

Data sources and measurement

We identified all suspected cases of OHCA managed by the Piedmont Emergency Medical Dispatch Centre, regardless of patient age, through the telephone dispatch code. Each case was included if subsequently confirmed as OHCA by the on-scene crew assessment. Inter-hospital transfers and cancelled dispatches (e.g., involvement of the continuing care service or caller withdrawal) were excluded.

From each medical record, we extracted the following variables: i) demographics: patient age and sex; ii) event characteristics: EMS response time of the first emergency unit, type of vehicle dispatched (BLS or ALS ambulance), location of the event (home, public place, workplace, street, sport facility, other), province, and urbanisation level (rural or urban); iii) clinical information: presumed cause of cardiac arrest (e.g., cardiovascular, respiratory, metabolic, traumatic, neurological, drug overdose, gastrointestinal, other, or unknown), as recorded by the responding unit; iv) bystander response: whether CPR was initiated (yes/no), and if so, whether it was started independently or dispatcher-assisted; v) outcomes: death or return of spontaneous circulation (ROSC) in the out-of-hospital setting.

The study was approved by the local Ethics Committee (CE187/2024). Data were extracted by authorized clinical personnel, anonymized with progressive numerical codes, and stored in an encrypted database developed using Microsoft Excel.

Statistical analysis

Categorical variables were summarized as absolute counts and percentages, while continuous variables were reported as means with standard deviations or medians with interquartile ranges, as appropriate. Group comparisons for categorical variables were performed using the chi-square test; when expected cell counts were <10, Fisher's exact test was applied. A p-value <0.05 was considered statistically significant. Statistical analyses were performed using Stata version 19 (StataCorp, College Station, TX, USA).

RESULTS

A total of 1,646 suspected OHCA cases were identified. Of these, 721 were excluded because on-scene crews did not confirm cardiac arrest, 18 due to cancelled dispatches, and 2 because they involved urgent inter-hospital transfers for time-dependent conditions. In total, 905 cases of cardiac arrest were confirmed during the study period (*Table 1*).

In 2022, the annual incidence of OHCA was 106 per 100,000 inhabitants (95% CI: 99-113). Most patients were male (57%), with a mean age of 76.4 years (±16). On average, men were younger than women (73.4 *vs* 80.5 years). The likely cause was mainly related to cardiovascular issues. Most events occurred at home (87%) and were managed by an ALS ambulance staffed with both a physician and a critical care nurse (80.3%), with a median response time of 8 minutes (IQR 5-13). In particular, the EMS response time was ≤5 minutes in 31.7% of cases (n=287) and ≤10 minutes in 64.3%.

In 28.8% of cases, medical records did not specify whether bystander CPR was performed. Among the 644 cases with available data, bystander CPR was reported in 39.9% (n=257), mostly initiated independently (90.7%).

ROSC in the out-of-hospital setting was achieved in 6.4% of patients. For this group of patients, the median EMS response time was 7 minutes (IQR 4-10).

Comparisons between cases with and without bystander-initiated CPR are reported in *Table 2*. Bystander CPR was significantly less frequent in OHCAs occurring at home compared with other locations (p<0.001). Similarly, the likelihood of bystander intervention was lower in urban areas (p=0.002), where median EMS arrival time was 6 minutes compared with 11 minutes in rural settings (p<0.001).

Overall, bystander CPR was associated with a higher probability of achieving ROSC in the out-of-hospital setting (p<0.001). Specifically, ROSC was more frequent in the home setting compared with other locations (p<0.001), while no significant difference was observed between rural and urban areas (p=0.415).

Table 1
Demographic and clinical characteristics of the 905 confirmed OHCA cases

	N=905	%
Sex, male*	518	57.24
Age, in years*		
<65	168	18.58
65-74	160	17.70
75-84	239	26.44
≥85	337	37.28
Presumed cause		
Cardiovascular	875	96.69
Neurological	19	2.10
Respiratory	4	0.44
Other	4	0.44
Trauma	2	0.22
Unknown causes	1	0.11
Province*		
n. 1	359	39.71
n. 2	187	20.69
n. 3	180	19.91
n. 4	172	19.03
Other	6	0.66
Level of urbanization*		
Rural	453	50.11
Urban	451	49.89
Location of the event		
Home	788	87.07
Street	45	4.97
Public place	12	1.33
Workplace	3	0.33
Sport facility	3	0.33
Other	54	5.97
Type of vehicle dispatched*		
ALS with physician and nurse	726	80.31
BLS	152	16.81
Helicopter	18	1.99
ALS with nurse	8	0.88
Arrival time		
Median time (Q1-Q3), in minutes	8 (5-13)	
Bystander CPR		
No	387	42.76
Yes	257	28.39
Not reported	261	28.83
CPR initiation by bystanders		
Independently	233	90.7
Dispatcher-assisted	24	9.3
Outcome*		
Death	843	93.56
ROSC in the out-of-hospital setting	58	6.44

*Missing data: sex (n=2), age (n=1), province (n=1), level of urbanization (n=1), type of vehicle dispatched (n=1), outcome (n=4); OHCA: out-of-hospital cardiac arrest; ALS: advanced life support; BLS: basic life support; CPR: cardiopulmonary resuscitation; ROSC: return of spontaneous circulation; Q1-Q3: first-third quartile.

DISCUSSION

The findings of this study, based on data from an Emergency Medical Dispatch Centre in Piedmont during 2022, offer new insights into the epidemiology of OHCA in this region. More than 40% of cases occurred in patients younger than 75 years, confirming that OHCA also affects a considerable proportion of relatively younger individuals. Bystander CPR was reported in 39.9% of cases with available data. CPR was most frequently initiated independently, and its occurrence was strongly associated with a higher probability of achieving ROSC in the out-of-hospital setting. Moreover, both home location and urban setting were

Table 2
Comparison of OHCA cases with and without bystander-initiated cardiopulmonary resuscitation

	Bystander CPR initiated N=257	Bystander CPR not initiated N=387	P-value
Sex, male*	154 (59.92)	219 (56.59)	0.444
Age, in years*			
<65	55 (21.40)	72 (18.65)	
65-74	59 (22.96)	72 (18.65)	0.255
75-84	70 (27.24)	107 (27.73)	
≥85	73 (28.40)	135 (34.88)	
Presumed cause			
Cardiovascular	246 (95.72)	376 (97.16)	0.325
Other cause	11 (4.28)	11 (2.84)	
Province**			
n. 1	114 (44.53)	141(36.81)	
n. 2	49 (19.14)	83 (21.67)	0.280
n. 3	47 (18.36)	82 (21.41)	
n. 4	46 (17.97)	77 (20.11)	
Level of urbanization*			
Rural	149 (57.98)	176 (45.60)	**0.002**
Urban	108 (42.02)	210 (54.40)	
Location of the event			
Home	183 (71.21)	358 (92.51)	
Street	24 (9.34)	14 (3.62)	
Public setting (public place, workplace, sport facility)	16 (6.23)	1 (0.25)	**<0.001**
Other	34 (13.22)	14 (3.62)	
Outcome			
Death	211 (83.07)	376 (97.41)	**<0.001**
ROSC in the out-of-hospital setting	43 (16.93)	10 (2.59)	

*Missing data: sex (n=2), age (n=1), level of urbanization (n=1); **for the province variable, four cases classified as "Other" were excluded; therefore, the denominator in the "Bystander CPR not initiated" group was 383.
OHCA: out-of-hospital cardiac arrest; CPR: cardiopulmonary resuscitation; ROSC: return of spontaneous circulation.
Bold values indicate statistically significant p-values (p<0.05).

linked to a lower likelihood of bystander intervention.

We identified an annual incidence of 106 OHCA per 100,000 inhabitants. This figure is consistent with European data, which report a mean incidence of 82.3 per 100,000 (95% CI: 31-243) [15] and aligns with the pooled estimate of a recent systematic review of 42 Italian studies, which found an incidence of approximately 86 per 100,000 (95% CI: 10-190) [6]. Although within the expected range, our estimate is slightly higher than both the Italian and European averages. Several factors may account for this difference, including the older age structure of the Piedmont population compared with the national average [26, 27] differences in EMS organization and case ascertainment [28] and potential regional variations in cardiovascular risk profiles, comorbidity burden, and lifestyle factors [29].

Notably, bystander CPR was initiated in almost 40% of cases. Although this estimate may be underestimated due to missing documentation in over one third of the medical records, the observed proportion falls below the European average (61%) [15], while exceeding pooled national estimates (26%) [6]. Importantly, with the observed higher likelihood of ROSC, our findings confirm the crucial role of bystander-initiated CPR in improving clinical outcomes [30], while carrying minimal risk of injury for patients [31]. To further increase CPR initiation, some system-level strategies have been proposed. For example, smartphone applications that alert trained volunteer responders in the vicinity of a cardiac arrest can reduce response times and improve the quality of resuscitation [14, 32]. This approach may be particularly valuable in settings where EMS arrival is delayed or where the presence of potential bystanders is limited, such as private homes or sparsely populated regions. In such contexts, the systematic involvement of first responders such as police officers or firefighters may prove especially effective, as they are often able to reach patients before medical teams, thereby contributing to higher survival rates [33, 34].

Most bystanders initiated CPR independently, without guidance from the Emergency Centre. This pattern may reflect the positive impact of regional public training initiatives and community awareness campaigns, which likely increased laypersons' confidence in responding to cardiac arrest. At the same time, it highlights a potential underutilization of dispatcher-assisted CPR, a key system-level intervention known to increase CPR rates and improve patient outcomes, particularly when bystanders are untrained or hesitant [35]. In Italy, the provision of standardized pre-arrival instructions by emergency dispatchers, covering basic CPR and the use of AEDs while awaiting emergency vehicles, is mandated by national legislation [36]. Nonetheless, notable regional differences persist in the adoption of protocols, availability of technological resources, and continuing education programs for dispatchers [37]. Optimizing dispatcher-assisted CPR depends not only on the technical content of the instructions but also on how they

are delivered. Innovations such as video support during emergency calls, simplified and standardized language, and the use of metronome cues or motivational prompts can enhance clarity, sustain compression quality, and increase bystander confidence [38]. Equally important are dispatcher-related factors, including dedicated training and the adoption of structured protocols or centralized systems, which together may strengthen the consistency and effectiveness of guidance provided to callers [38].

In our cohort, ROSC was achieved in only 6% of cases, a lower proportion compared with international studies [15, 30]. However, it is important to note that our analysis considered only ROSC documented in the pre-hospital context. It is therefore plausible that additional cases of ROSC occurred after hospital admission, which would not have been captured in our data.

Interestingly, we observed a higher frequency of bystander CPR initiation in rural areas compared with urban settings, a trend consistent with previous reports [39, 40]. This phenomenon may be partly explained by longer EMS response times in less populated areas, which provide bystanders with greater opportunity to intervene, as well as by psychological factors such as a reduced bystander effect and lower "urban overload" in low-density settings [39].

Similarly, we found that witness intervention was more frequent in public spaces such as streets or other non-residential locations, whereas bystander CPR rates were significantly lower in private homes. This finding is consistent with Ting *et al*. [41], who also reported a lower incidence of bystander intervention in residential settings. Such differences may reflect the greater availability of potential witnesses in public areas, while arrests occurring at home are disadvantaged by fewer bystanders and limited access to life-saving devices. The findings highlight the need to strengthen community preparedness and system-level strategies to increase bystander CPR rates. From a clinical and educational perspective, integrating BLS training into school curricula, workplaces, and community programs could improve public responsiveness and confidence in emergency situations. Organizationally, enhancing dispatcher-assisted CPR through structured protocols, continuous dispatcher education, and the use of real-time digital tools may further optimize early intervention. For policymakers, the results support the establishment of standardized regional or national cardiac arrest registries and the implementation of coordinated awareness campaigns to promote a "culture of rescue", ultimately improving survival outcomes after OHCA.

Although the composition of EMS crews was not captured in our dataset, emerging evidence suggests that prehospital models incorporating advanced nursing roles may influence clinical outcomes. Recent studies report that the presence of emergency nurse practitioners within EMS teams can increase ROSC rates up to fourfold, highlighting the potential contribution of advanced nursing practice in the early phases of cardiac arrest management [42]. In addition, airway management performed by ambulance nurses has been shown to be safe and effective, with high first-pass success rates for supraglottic devices and improving endotracheal intubation performance over time [43].

While the use of data collected over an entire year ensures a comprehensive and representative picture of OHCA cases in the region, some study limitations should be considered. First, the retrospective nature of the data may have introduced inaccuracies. Second, the information on the use of AEDs and data on initial cardiac rhythm were not available, preventing us from assessing their contribution to resuscitation outcomes. Third, survival data beyond the pre-hospital phase were not collected, which restricted our ability to evaluate longer-term outcomes such as survival to hospital discharge or neurological status. Finally, the registry did not allow us to distinguish between interventions performed by lay bystanders and those initiated by trained lay-responders, limiting our capacity to explore potential differences between these groups. These gaps underscore the importance of adopting more detailed and standardized data collection frameworks, to ensure consistent definitions, reduce heterogeneity, and improve the comparability of outcomes across registries [44].

CONCLUSIONS

This study offers an updated overview of OHCA in the Piedmont region, with an incidence comparable to national and European data. Bystander CPR, although associated with higher ROSC rates, was initiated in fewer than half of cases, particularly in the home setting and rural context. These findings stress the importance of strengthening public training and optimizing dispatcher-assisted CPR to improve outcomes.

Conflicts of interest statement

The Authors declare no conflicts of interest related to this study.

Generative AI declaration statement

During the preparation of this work the Authors used ChatGPT (OpenAI) in order to improve language and readability. After using this tool/service, the Authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Received on 9 December 2025.
Accepted on 28 April 2026.

REFERENCES

1. Gräsner JT, Lefering R, Koster RW, Masterson S, Böttiger BW, Herlitz J, et al. EuReCa ONE-27 Nations, ONE Europe, ONE Registry: a prospective one month analysis of out-of-hospital cardiac arrest outcomes in 27 countries in Europe. Resuscitation. 2016;105:188-95.
2. Böttiger BW, Becker LB, Kern KB, Lippert F, Lockey A, Ristagno G, Semeraro F, Wingen S. BIG FIVE strategies for survival following out-of-hospital cardiac arrest.

Eur J Anaesthesiol. 2020;37(11):955-8. doi: 10.1097/EJA.0000000000001247
3. Gräsner JT, Herlitz J, Tjelmeland IBM, Wnent J, Masterson S, Lilja G, et al. European Resuscitation Council Guidelines 2021: epidemiology of cardiac arrest in Europe. Resuscitation. 2021;161:61-79.
4. Kiguchi T, Okubo M, Nishiyama C, Maconochie I, Ong MEH, Kern KB, Wyckoff MH, McNally B, Christensen EF, Tjelmeland I, Herlitz J, Perkins GD, Booth S, Finn J, Shahidah N, Shin SD, Bobrow BJ, Morrison LJ, Salo A, Baldi E, Burkart R, Lin CH, Jouven X, Soar J, Nolan JP, Iwami T. Out-of-hospital cardiac arrest across the world: first report from the International Liaison Committee on Resuscitation (ILCOR). Resuscitation. 2020;152:39-49. doi: 10.1016/j.resuscitation.2020.02.044
5. Zheng J, Lv C, Zheng W, Zhang G, Tan H, Ma Y, Zhu Y, Li C, Han X, Yan S, Pan C, Zhang J, Hou Y, Wang C, Bian Y, Liu R, Cheng K, Ma J, Zheng Z, Song R, Wang M, Gu J, McNally B, Ong MEH, Chen Y, Xu F; BASIC-OHCA Coordinators and Investigators. Incidence, process of care, and outcomes of out-of-hospital cardiac arrest in China: a prospective study of the BASIC-OHCA registry. Lancet Public Health. 2023;8(12):e923-32. doi: 10.1016/S2468-2667(23)00173-1
6. Scquizzato T, Gamberini L, D'Arrigo S, Galazzi A, Babini G, Losiggio R, et al. Incidence, characteristics, and outcome of out-of-hospital cardiac arrest in Italy: a systematic review and meta-analysis. Resusc Plus. 2022;12:100329.
7. Gräsner JT, Wnent J, Herlitz J, Perkins GD, Lefering R, Tjelmeland I, Koster RW, Masterson S, Rossell-Ortiz F, Maurer H, Böttiger BW, Moertl M, Mols P, Alihodžić H, Hadžibegović I, Ioannides M, Truhlář A, Wissenberg M, Salo A, Escutnaire J, Nikolaou N, Nagy E, Jonsson BS, Wright P, Semeraro F, Clarens C, Beesems S, Cebula G, Correia VH, Cimpoesu D, Raffay V, Trenkler S, Markota A, Strömsöe A, Burkart R, Booth S, Bossaert L. Survival after out-of-hospital cardiac arrest in Europe – Results of the EuReCa TWO study. Resuscitation. 2020;148:218-26.
8. Perkins GD, Graesner JT, Semeraro F, Olasveengen T, Soar J, Lott C, Van de Voorde P, Madar J, Zideman D, Mentzelopoulos S, Bossaert L, Greif R, Monsieurs K, Svavarsdóttir H, Nolan JP; European Resuscitation Council Guideline Collaborators. European Resuscitation Council Guidelines 2021: executive summary. Resuscitation. 2021;161:1-60. doi: 10.1016/j.resuscitation.2021.02.003. Erratum in: Resuscitation. 2021;163:97-8. doi: 10.1016/j.resuscitation.2021.04.012
9. Song J, Guo W, Lu X, Kang X, Song Y, Gong D. The effect of bystander cardiopulmonary resuscitation on the survival of out-of-hospital cardiac arrests: a systematic review and meta-analysis. Scand J Trauma Resusc Emerg Med. 2018;26(1):86. doi: 10.1186/s13049-018-0552-8
10. Sasson C, Rogers MAM, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes. 2010;3(1):63-81.
11. Semeraro F, Greif R, Böttiger BW, Burkart R, Cimpoesu D, Georgiou M, et al. European Resuscitation Council Guidelines 2021: systems saving lives. Resuscitation. 2021;161:80-97.
12. Schroeder DC, Semeraro F, Greif R, Bray J, Morley P, Parr M, Kondo Nakagawa N, Iwami T, Finke SR, Malta Hansen C, Lockey A, Del Rios M, Bhanji F, Sasson C, Schexnayder SM, Scquizzato T, Wetsch WA, Böttiger BW; International Liaison Committee on Resuscitation. KIDS SAVE LIVES: basic life support education for schoolchildren: a narrative review and scientific statement from the International Liaison Committee on Resuscitation. Circulation. 2023;147(24):1854-68. doi: 10.1161/CIR.0000000000001128. Erratum in: Circulation. 2023;148(1):e1. doi: 10.1161/CIR.0000000000001166
13. Böttiger BW, Lockey A, Aickin R, Castren M, De Caen A, Escalante R, et al. All citizens of the world can save a life – The World Restart a Heart (WRAH) initiative starts in 2018. Resuscitation. 2018;128:188-90.
14. Yu Y, Meng Q, Munot S, Nguyen TN, Redfern J, Chow CK. Assessment of community interventions for bystander cardiopulmonary resuscitation in out-of-hospital cardiac arrest: a systematic review and meta-analysis. JAMA Netw Open. 2020;3(7):e209256.
15. Gräsner JT, Wnent J, Lefering R, Herlitz J, Masterson S, Maurer H, Perkins GD, Ortiz FR, Tjelmeland IBM, Kamishi D, Moertl M, Mols P, Alihodzic H, Ioannides M, Truhlář A, Baert V, Nikolaou N, Molnar N, Jonsson BS, Semeraro F, Krikscionaitiene A, Clarens C, Giordimaina C, Stieglis R, Zadlo A, Correia VH, Cimpoesu D, Raffay V, Trenkler S, Strnad M, Ruiz JI, Strømsøe A, Wilmes A, Booth S, Bossaert L; EuReCa-THREE collaborator group. European registry of cardiac arrest study THREE (EuReCa-THREE) – EMS response time influence on outcome in Europe. Resuscitation. 2026;223:110704. doi: 10.1016/j.resuscitation.2025.110704
16. Aldridge ES, Perera N, Ball S, Finn J, Bray J. A scoping review to determine the barriers and facilitators to initiation and performance of bystander cardiopulmonary resuscitation during emergency calls. Resusc Plus. 2022;11:100290. doi: 10.1016/j.resplu.2022.100290
17. Farquharson B, Dixon D, Williams B, Torrens C, Philpott M, Laidlaw H, et al. The psychological and behavioural factors associated with laypeople initiating CPR for out-of-hospital cardiac arrest: a systematic review. BMC Cardiovasc Disord. 2023;23(1):19.
18. Van Nieuwenhuizen BP, Oving I, Kunst AE, Daams J, Blom MT, Tan HL, et al. Socio-economic differences in incidence, bystander cardiopulmonary resuscitation and survival from out-of-hospital cardiac arrest: a systematic review. Resuscitation. 2019;141:44-62.
19. Shekhar A, Narula J. Globally, GDP per capita correlates strongly with rates of bystander CPR. Ann Glob Health. 2022;88(1):36. doi: 10.5334/aogh.3624
20. Uny I, Angus K, Duncan E, Dobbie F. Barriers and facilitators to delivering bystander cardiopulmonary resuscitation in deprived communities: a systematic review. Perspect Public Health. 2023;143(1):43-53. doi: 10.1177/17579139211055497
21. Cheng Y, Zhang C, Chen L, Liu H, He W, Shi Z. Public participation willingness in out-of-hospital cardiopulmonary resuscitation: a systematic review and meta-analysis. Int J Nurs Sci. 2025;12(2):192-9. doi: 10.1016/j.ijnss.2025.02.012
22. Siddiqui FJ, McNally B, Gräsner JT, Ho AFW, Tjelmeland I, Iwami T, Bray J, Wnent J, Lynn Lim S, Pin Pek P, Do Shin S, Ong MEH; GOHCAR Group. Towards advancing out-of-hospital cardiac arrest (OHCA) registries globally: considerations from the global OHCA registry (GOHCAR) collaborative. Resusc Plus. 2024;18:100615. doi: 10.1016/j.resplu.2024.100615
23. Azienda Zero. La storia di Azienda Zero. Torino: Regione Piemonte. [last access 22/09/2025]. Available from: https://www.aziendazero.piemonte.it/azienda/la-storia-di-azienda-zero/
24. Tabi M, Perel N, Taha L, Amsalem I, Hitter R, Maller T, Manassra M, Karmi M, Zacks N, Levy N, Shrem M, Marmor D, Gavriel D, Jarjoui A, Shuvy M, Asher E; Jeru-

salem Platelets Thrombosis and Intervention in Cardiology (JUPITER-9) Study Group. Out of hospital cardiac arrest – new insights and a call for a worldwide registry and guidelines. BMC Emerg Med. 2024;24(1):140. doi: 10.1186/s12873-024-01060-4
25. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008;61(4):344-9. doi: 10.1016/j.jclinepi.2007.11.008
26. Eurostat. Population structure and ageing. Luxembourg: Eurostat; 2026. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing
27. Istituto Nazionale di Statistica. Il Censimento permanente della popolazione in Piemonte. Roma: ISTAT; 2025. Available from: https://www.istat.it/wp-content/uploads/2025/04/Censimento-permanente-popolazione_Anno-2023_Piemonte.pdf
28. Parvez SS, Parvez S, Ullah I, Parvez SS, Ahmed M. Systematic review on the worldwide disparities in the frequency and results of Emergency Medical Services (EMS) and response to out-of-hospital cardiac arrest (OHCA). Cureus. 2024;16(6):e63300. doi: 10.7759/cureus.63300
29. SCORE2 Working Group and ESC Cardiovascular Risk Collaboration. SCORE2 risk prediction algorithms: new models to estimate 10-year risk of cardiovascular disease in Europe. Eur Heart J. 2021;42(25):2439-54. doi: 10.1093/eurheartj/ehab309
30. Yan S, Gan Y, Jiang N, Wang R, Chen Y, Luo Z, Zong Q, Chen S, Lv C. The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. Crit Care. 2020;24(1):61. doi: 10.1186/s13054-020-2773-2
31. Ng JYX, Sim ZJ, Siddiqui FJ, Shahidah N, Leong BS, Tiah L, Ng YY, Blewer A, Arulanandam S, Lim SL, Ong MEH, Ho AFW. Incidence, characteristics and complications of dispatcher-assisted cardiopulmonary resuscitation initiated in patients not in cardiac arrest. Resuscitation. 2022;170:266-73. doi: 10.1016/j.resuscitation.2021.09.022
32. Kern M, Jansen G, Strickmann B, Kerner T. Advancements in public first responder programs for out-of-hospital cardiac arrest: an updated literature review. Rev Cardiovasc Med. 2025;26(1):26140. doi: 10.31083/rcm26140
33. Hansen CM, Kragholm K, Granger CB, Pearson DA, Tyson C, Monk L, Corbett C, Nelson RD, Dupre ME, Fosbøl EL, Strauss B, Fordyce CB, McNally B, Jollis JG. The role of bystanders, first responders, and emergency medical service providers in timely defibrillation and related outcomes after out-of-hospital cardiac arrest: Results from a statewide registry. Resuscitation. 2015;96:303-9. doi: 10.1016/j.resuscitation.2015.09.002
34. El-Zein RS, Kennedy KF, Chang P. Out-of-hospital cardiac arrest survival when CPR is initiated by first responders. Resuscitation. 2023;190:109914. doi: 10.1016/j.resuscitation.2023.109914
35. Nikolaou N, Dainty KN, Couper K, Morley P, Tijssen J, Vaillancourt C; International Liaison Committee on Resuscitation's (ILCOR) Basic Life Support and Pediatric Task Forces. A systematic review and meta-analysis of the effect of dispatcher-assisted CPR on outcomes from sudden cardiac arrest in adults and children. Resuscitation. 2019;138:82-105. doi: 10.1016/j.resuscitation.2019.02.035
36. Italia. Legge 4 agosto 2021, n. 116. Disposizioni in materia di utilizzo dei defibrillatori semiautomatici e automatici esterni. Gazzetta Ufficiale – Serie Generale n. 193, 13 agosto 2021. Available from: https://www.gazzettaufficiale.it/eli/id/2021/08/13/21G00126/sg
37. Imbriaco G, Canova GS, Righi L, Tararan S, Di Mario G, Ramacciati N. Dispatcher-assisted CPR in Italy: a nationwide survey of current practices and future challenges in emergency medical communication centers. J Clin Med. 2025;14(2):637. doi: 10.3390/jcm14020637
38. Dainty KN, Debaty G, Waddick J, Vaillancourt C, Malta Hansen C, Olasveengen T, Bray J; International Liaison Committee on Resuscitation Basic Life Support Task Force. Interventions to optimize dispatcher-assisted CPR instructions: a scoping review. Resusc Plus. 2024;19:100715. doi: 10.1016/j.resplu.2024.100715
39. Nikonowicz P, Huebinger R, Al-Araji R, Schulz K, Gill J, Villa N, McNally B, Bobrow B. Rural cardiac arrest care and outcomes in Texas. Am J Emerg Med. 2024;78:57-61. doi: 10.1016/j.ajem.2023.12.033
40. Gregers MCT, Møller SG, Kjoelbye JS, Jakobsen LK, Grabmayr AJ, Kragh AR, Hansen CM, Torp-Pedersen C, Andelius L, Ersbøll AK, Folke F. Association of degree of urbanization and survival in out-of-hospital cardiac arrest. J Am Heart Assoc. 2023;12(10):e8322. doi: 10.1161/JAHA.122.028449
41. Ting PZY, Ho AFW, Lin X, Shahidah N, Blewer A, Ng YY, Leong BS, Gan HN, Mao DR, Chia MYC, Cheah SO, Ong MEH. Nationwide trends in residential and non-residential out-of-hospital cardiac arrest and differences in bystander cardiopulmonary resuscitation. Resuscitation. 2020;151:103-10. doi: 10.1016/j.resuscitation.2020.03.007
42. Kaewpaengchan W, Wongtanasarasin W, Khampeera W, Wittayachamnankul B. The impact of emergency nurse practitioners on short-term survival in out-of-hospital cardiac arrest. Australas Emerg Care. 2025;28(3):163-6. doi: 10.1016/j.auec.2025.02.002
43. Doeleman LC, de Jong JFF, van Eeden VGM, Schober P, Hollmann MW, van Schuppen H. Airway management by ambulance nurses during out-of-hospital cardiac arrest. Resusc Plus. 2025;25:100999. doi: 10.1016/j.resplu.2025.100999
44. Gräsner JT, Bray JE, Nolan JP, Iwami T, Ong MEH, Finn J, McNally B, Nehme Z, Sasson C, Tijssen J, Lim SL, Tjelmeland I, Wnent J, Dicker B, Nishiyama C, Doherty Z, Welsford M, Perkins GD; International Liaison Committee on Resuscitation. Cardiac arrest and cardiopulmonary resuscitation outcome reports: 2024 update of the Utstein out-of-hospital cardiac arrest registry template. Resuscitation. 2024;201:110288. doi: 10.1016/j.resuscitation.2024.110288